Current distribution in the welded YBCO bulk material

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Abstract

Detailed measurements of magnetic penetration into the welded YBCO bulk materials were performed by means of magneto-optical techniques. We compared the current distribution in two kinds of the welded joints with controlled crystallographic surfaces: the (110)/(110) joint and the (100)/(100) joint. It was found that the connectivity of the (110)/(110) was superior to that of the (100)/(100) joint.

Key words: magneto-optical measurement;YBCO;critical current density;grain boundary

1. Introduction

Bulk superconductors have significant potential for industrial applications such as magnetic levitation and quasi-permanent magnets with high trapped-fields. Unlike conventional permanent magnets, magnetic field trapped in the superconducting bulk magnet is generated by superconducting persistent current circulating in the material. Hence, a trapped-field can be increased either by increasing the critical current density (J_c) or the size of a current loop.

The welding technique, which consists in joining two single domain bulk superconductors with a compound having lower peritectic temperature, is considered to be one of the most promising techniques in obtaining large size bulk materials. In this study, we investigated the effect of crystallographic surfaces of the joints on the connectivity of current path.

2. Experimental

Two Y-Ba-Cu-O blocks having surfaces perpendicular to $< 110 >$ direction (denoted as the (110)/(110) joint) were joined using Er-Ba-Cu-O solders. Details of the preparation of Er-Ba-Cu-O solder and the heat-profile for welding can be found elsewhere. [1] We also welded two Y-Ba-Cu-O blocks having surfaces perpendicular to $< 100 >$ direction in the same way. Small specimens with dimensions approximately $2.0 \times 2.2 \times 0.5$ mm^3 were cut from the joint and used for the present study.

A magneto-optical (MO) observation of magnetic field distribution was performed using a ferromagnetic Bi-doped yttrium iron garnet thin film with in-plane anisotropy. The field was oriented perpendicular to the sample surface.

3. Results and Discussion

Figure 1 (a) shows field profiles of the (100)/(100) joint sample across the boundary at 15 K. Applied magnetic field was increased from 100 G to 1000 G in 100 G step. We can see the sample completely shields the

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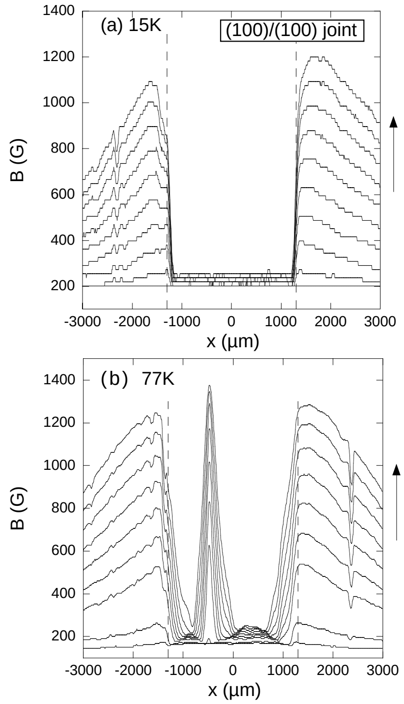

Fig. 1. Field profiles across the (100)/(100) joint during an increasing magnetic field process from 100 G to 1000G. (a) T = 15 K. (b) T = 77 K.

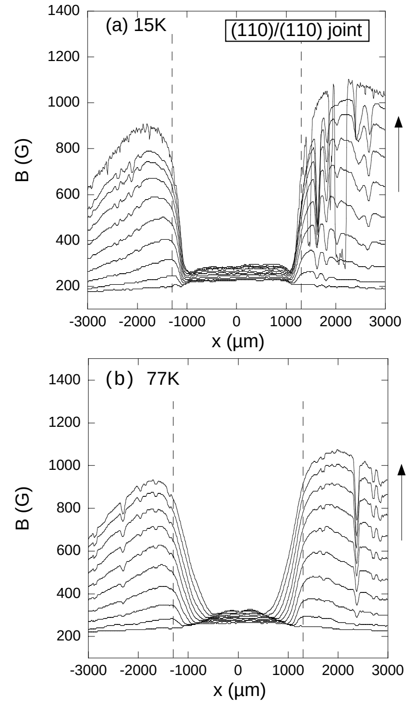

Fig. 2. Field profiles across the (110)/(110) joint during an increasing magnetic field process from 100 G to 1000G. (a) T = 15 K. (b) T = 77 K

magnetic fields and behaves like a single grain sample. In contrast, as shown in Fig. 1 (b), at 77 K field penetration starts as low as 200 G, from the joint, and behave like isolated two grains. This indicates that the current flow across the (100)/(100) joint is inhibited at high temperatures.

On the other hand, in the case of (110)/(110) joint sample, no flux penetration into the joint region was observed both at 15 K and 77 K. (Fig.2) These results imply that two Y-Ba-Cu-O grains are strongly coupled in the (110)/(110) joint.

Such a large difference in the flux penetration behavior originates from a difference in microstructure of the joint region. In the case of the (100)/(100) joint, Er_2BaCuO_5 (Er211) particles segregated at the center of the joint. In addition, impurity phases associated with the residual liquid phase were also present at the joint interface. By contrast, in the case of the (110)/(110) joint, we did not find such phases at the joint region.

4. Conclusion

Magnetic field penetration into the welded YBCO bulk samples was observed using magneto-optical techniques. We compare the magnetic profile for two kinds of samples having different crystal orientation. We found the magnetic coupling at the (110)/(110) joint is much stronger than that of the (100)/(100) joint, which can be attributed to a difference in the microstructure at the joint interfaces.

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